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OPTIMIZATION

OF THE

CARAMAT WATER TREATMENT PLANT

FOR

CONTROL OF TRIHALOMETHANES

SEPTEMBER 1997

Ontario

Ministry of
Environment
and Energy

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Report prepared for:

Standards Development Branch
Ontario Ministry of Environment and Energy

EXECUTIVE SUMMARY

BACKGROUND

The two main objectives of the study are:

1. Improvement of the water treatment plant performance to meet the new Ontario Drinking Water Objectives (ODWO) THM guideline, without compromising disinfection to achieve a filter effluent turbidity of 0.1 NTU, and to meet the aluminum operational guideline of 100 μg/L.

2. Sustaining long term performance through skills transfer to plant operating staff and recommendations for plant upgrades where required.

The optimization study was funded by the Ontario Ministry of Environment and Energy (MOEE), and is a cooperative public/private project between the MOEE and RAL Engineering Ltd. By optimizing the performance of their existing facilities, municipalities should be capable of producing water that meets the new THM objective, and also be capable of improved particle removal and lower aluminum residuals, without requiring costly upgrades.

Trihalomethanes (THMs) are by-products created when the chlorine used in the disinfection process reacts with naturally occurring organics. Trihalomethanes are suspected of increasing the risk of cancer following long term exposure. The Ontario government has lowered the guideline from a maximum acceptable concentration of 350 μg/L, measured as a single occurrence, to an interim maximum acceptable concentration of 100 μg/L based on a running annual average of four quarterly samples.

The associated treatment parameters of turbidity and aluminum residual were also subject of the optimization effort. The ODWO for turbidity is 1 NTU, but current research now indicates that a filter effluent turbidity of 0.1 NTU is needed to provide protection from cryptosporidium. To reduce potential for disease outbreaks, this study will evaluate the feasibility of obtaining a turbidity of 0.1 NTU in the filter effluent. The ODWO operational guideline (not health related) for aluminum in drinking water is 100 μg /L

The optimization of a water treatment plant consists of evaluating the existing treatment units, conducting laboratory testing to determine the best choice and dosage of the treatment chemicals and implementing changes to plant operation.

EXISTING CONDITIONS

The Community of Caramat Water Treatment Plant was up-graded in 1994 and consists of an intake from Caramat Lake, a raw water pump, and a Napier Reid filter unit consisting of a dual media filter followed by a GAC contactor. There is no provision for the addition of pre-treatment chemicals. The effluent from the filter is chlorinated and is discharged to a relatively large clearwell/reservoir. The original plant had a concrete basin with a mixing flocculation chamber and a settling tank however, it is not piped into the present treatment process. The plant is operated by Caramat Local Services Board.

A summary of historical data from June 1995 to May 1996 is presented as follows:

Parameters	*Units*	*Raw Water*	*Treated Water*
Turbidity	NTU	1 to 5	0.6
Colour	TCU	40 to 70	2 to 5
pH		7.4 to 7.9	6.9 to 7.4
Alkalinity	mg/L -$CaCO_3$	30 to 57	21 to 44
THM (distribution system)	μg/L		100 to 150

Plant flows are generally:	Average day	75 m^3/d
	Maximum daily flow	105 m^3/d.
	Rated Plant Capacity	95 m^3/d

PERFORMANCE ASSESSMENT

The Caramat Lake supply is high in colour and Total Organic Carbon (TOC) and low in turbidity. The existing treatment process of direct filtration with no pre-treatment chemicals does not remove turbidity. Cyst sized particles pass through the filter into the clearwell. In addition, the activated carbon can effectively remove the organics that will form THMs but, the carbon becomes saturated after only three months of operation and the cost of replacement is excessively high. The community has never replaced the carbon. Consequently, the current plant does not provide effective treatment and relies completely on chlorine disinfection to produce a safe water. Colour and THMs are high in the plant effluent.

CONCLUSIONS

There is little that can be done to make the existing plant produce water that will meet the objectives. The high level of organics in the raw water must be removed prior to chlorination to reduce THM formation. The activated carbon is capable of this treatment but only for a limited time and the cost of carbon replacement is high. In addition the plant is not capable of significantly lowering turbidity without pre-treatment chemicals. Full treatment is required to produce water that meets the Ontario Drinking Water Objectives.

RECOMMENDATIONS FOR PLANT SCALE MODIFICATIONS

It is recommended that the Caramat Water Treatment Plant be up-graded to full treatment with the addition of the necessary chemical feed systems, rapid mix, flocculation, and sedimentation. This could be accomplished in one of two ways:

OPTION 1: Addition Of New Pre-Treatment Unit

OPTION 2: Rehabilitation Of Existing Concrete Unit

The existing concrete treatment tankage built in the original plant construction appears to be serviceable with only a minor overhaul.

If the community proceeds with the up-grade it is also recommended that the plant operator receive training in the use of the treatment chemicals.

COST ESTIMATE FOR IMPLEMENTATION

The following table is a summary of capital expenditure involved in the implementation of the recommended up-grades. The figures presented are preliminary estimates prepared to give an idea of the price range involved.

Capital Cost Estimates

OPTION 1: Addition Of New Pre-Treatment Unit	**$123,410 (Taxes not included)**
OPTION 2: Rehabilitation Of Existing Concrete Unit	**$ 90,000 (Taxes not included)**

Annual Operation Costs for Options 1 and 2

OPTION 1 and OPTION 2	**$31,050 (Taxes not included)**

Amortization over 20 years including Capital and Operation Costs

OPTION 1: Addition Of New Pre-Treatment Unit	**$440 per year per household**
	($37 per month per household)
OPTION 2: Rehabilitation Of Existing Concrete Unit	**$400 per year per household**
	($34 per month per household)

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1.0 BACKGROUND

Trihalomethanes (THMs) are by-products created when the chlorine used in the disinfection process reacts with naturally occurring organics (eg. formed by decay of algae and vegetation) in raw water. Surface water containing high organics also often have high colour levels. The most common forms of trihalomethanes created are chloroform, bromodichloromethane, chlorodibromomethane and bromoform.

The formation of THMs is influenced by several factors:

• Free chlorine concentration	- higher Cl_2	= higher THM
• Organic content	- higher organic concentration	= higher THM
• pH	- higher pH	= higher THM
• Temperature	- higher temperature	= higher THM
• Time	- generally longer time	= higher THM

Since the formation of trihalomethanes is associated with the presence of organics in the water, small inland lakes and rivers, which may contain more organics than large clear bodies of water have a greater trihalomethane formation potential, especially during periods of high runoff.

The reason for adding chlorine to drinking water is to inactivate bacteria and other microorganisms that can cause numerous illnesses. However, chlorine use leads to the presence of trihalomethanes and this is a cause for concern; studies have found an association between high levels of trihalomethanes in chlorinated drinking water, and slight increases in cancer following long term exposure of more than 35 years.

Chlorine has an advantage over other disinfectants in that it persists many hours or for days and provides protection for the entire water distribution system. The benefit to public health of using chlorine as a disinfectant in drinking water far out-weighs the risk to health associated with the low levels of trihalomethanes created as by-products of chlorination.

In order to decrease the health risk from trihalomethanes, the Canadian and Ontario governments have lowered their respective guideline limits from an "anytime" maximum acceptable concentration of 350 μg/L, to an interim maximum acceptable concentration of 100 μg/L based on a running annual average of four quarterly samples.

Disease outbreaks caused by giardia and cryptosporidium have been reported with increased frequency over the last decade in Canada and the US. These protozoan parasites (especially cryptosporidium) are more difficult to kill than bacteria with disinfectants, and therefore their removal by physical processes is vital. As a result, Health Canada is now examining the need for stricter standards for particle removal in water plants. The current Ontario Drinking Water Objective (ODWO) for turbidity that applies at the water treatment plant is 1 NTU, but current US research and experience now indicate that a filter effluent turbidity of 0.1 NTU is needed to provide protection from cryptosporidium. In the attempt to reduce potential for disease outbreaks, this study attempted to evaluate the feasibility to obtain a turbidity of 0.1 NTU in filter effluent.

Alum (aluminum sulphate) is the most widely used coagulant because it is effective, readily available, and relatively inexpensive. However, under some circumstances, or if not used properly, its use can result in elevated levels of residual aluminum in finished drinking water. An article was recently published on facts about human health and aluminum in drinking water (Environmental Science and Engineering Magazine, January 1997). The following is a summary of the major facts presented in the article.

In recent years, increased attention has been focused on possible adverse effects of aluminum in drinking water on human health. Several epidemiological studies have reported a slightly increased incidence of dementia in communities where drinking water is high in aluminum and these studies have raised concerns among the media and public.

A number of theories on the causes of Alzheimer's disease have been proposed and are currently under investigation. From what we know at this time, the evidence linking aluminum and Alzheimer's disease is far from conclusive, but we also cannot be sure that there is no relationship. Humans are constantly being exposed to aluminum via food, air, and water. Ninety percent (90%) of aluminum intake is from food. In general, exposure to aluminum from drinking water is very low (below 3%) compared with that from food and drugs. At the present time the ODWO for aluminum in drinking water is 100 ug/L, which is an operational not health related guideline.

Owners of water treatment plants and water distribution systems who provide water for consumption have legal responsibilities which are shared by all suppliers of food or drink. Owners and suppliers must take all reasonable measures to ensure the water is fit for consumption.

This optimization study is funded by the Ontario Ministry of Environment and Energy (MOEE), and is a cooperative public/private project between the MOEE and RAL Engineering Ltd. By optimizing the performance of their existing facilities, municipalities with a conventional water treatment plant (i.e. coagulation, flocculation, settling, filtration and disinfection) in many cases should be capable of producing water that meets the new THM objective, and also be capable of improved particle removal, without resorting to costly upgrades.

The optimization of a water treatment plant consists of:

- Documentation of existing facility;
- Assessment of the performance of each process unit;
- Verification of the hydraulic loading on each process;
- Laboratory jar testing to determine the best combination of treatment chemicals and the optimum dosages to achieve maximum removal of particulates and dissolved organic material, as well as a minimum level of aluminum residual in the treated water;
- Implementation of necessary changes to plant operation to ensure that changes will minimize the formation of THM, but will not compromise the disinfection requirement.

2.0 OBJECTIVES

The two main objectives of the study are:

1. IMPROVEMENT OF CARAMAT WATER TREATMENT PLANT PERFORMANCE

- Improve plant performance without major capital/equipment expenditures. Specific water quality objectives are listed below in decreasing order of priority:

  A. To comply with the 100 µg/L ODWO for THMs in treated water as a running annual average of four quarterly samples. This objective shall be met while ensuring proper removal and/or inactivation of disease-causing organisms such as bacteria and viruses, since this remains the most critical aspect of drinking water treatment.

  B. To improve particulate removal to reduce or eliminate disease risk from giardia and cryptosporidium. While the ODWO for turbidity is 1.0 NTU, the goal is to achieve 0.1 NTU in the filter effluent.

  C. To keep aluminum residual at or below 100 µg/L to meet the ODWO.

2. SUSTAINING LONG-TERM PERFORMANCE

- Skills transfer to plant operating staff to enable them to effectively control and adjust processes over the long term in response to raw water quality variations.
- Documentation of plant conditions with recommendations for up-grades and operational modifications.

3.0 DOCUMENTATION OF EXISTING CONDITIONS

The source of the raw water for the Caramat Water Treatment Plant is Caramat Lake. The rated plant capacity is 95 m^3/d (66 L/min). The plant was up-graded in 1994 with the addition of a package dual media filter and a Granular Activated Carbon (GAC) contactor. There is no chemical feed system used except for chlorine. It is reported the GAC "lasted" about three months before saturation, and has not been replaced due to the cost.

The plant has a large unbaffled clearwell providing one and a half days storage. There is a much older rapid mix tank and clarifier from the original plant, however, these are not being used due to incompatible hydraulic levels and lack of full time operation.

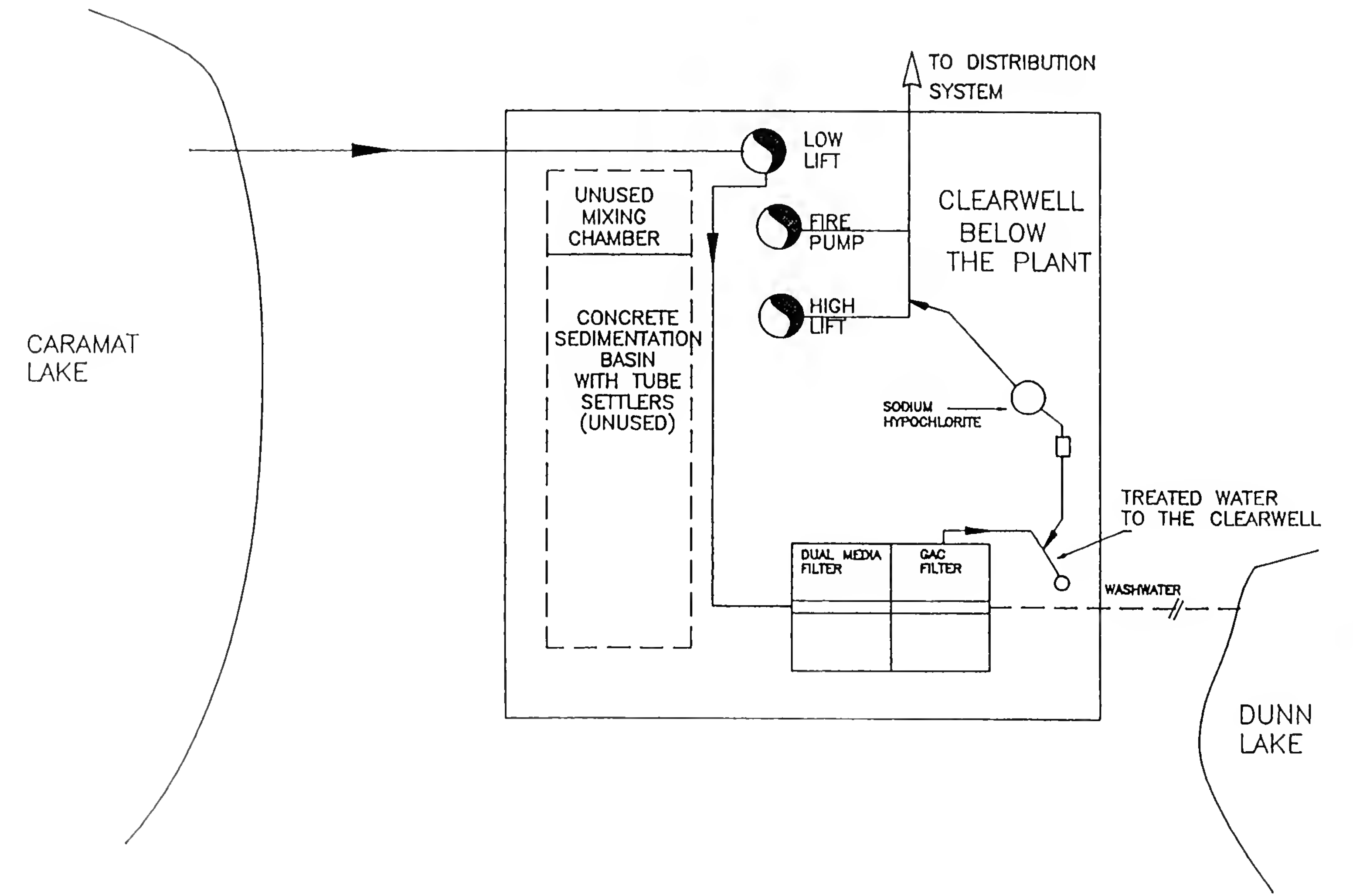
The raw water characteristics are:

Colour:	40 to 70 TCU
Turbidity:	1 to 5 NTU
pH:	7.4 to 7.9
Alkalinity:	30 to 57 mg/L

Plant flows are:

Rated Plant Capacity:	95 m^3/d (1.1 L/s)
Average Daily Flow:	75 m^3/d (0.9 L/s)
Max. Daily Flow:	105 m^3/d (1.2 L/s)

The plant is operated approximately 24 hours per day, all year round. A plant survey was performed on a site visit by the MOEE and RAL Engineering, on June 18, 1996, to prepare a description of existing equipment and condition of operation. Additional survey material is presented in Appendix A, and a flow schematic of the plant on Figure 3.1.



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CARAMAT WATER TREATMENT PLANT SCHEMATIC

SCALE	FIGURE
NTS	3.1

3.1 TREATMENT PROCESS UNITS

Rated Plant Capacity:	66 L/min
Average Daily Flow:	52 L/min
Maximum daily Flow:	73 L/min (Higher than rated plant capacity)
Low Lift Pumps:	1 low lift pump rated at 66 L/min
High Lift Pumps:	1 high lift pump rated at 360 L/min
Sedimentation:	Not Applicable
Dual Media Filter:	
Number:	1
Type:	Napier-Reid dual media (sand/anthracite)
Dimensions:	0.8 m by 1.2 m
GAC Filter:	
Number:	1
Type:	Napier-Reid GAC filter
Dimensions:	1.4 m by 1.2 m
Clearwell:	142 m^3 reservoir with no baffle 6.2 m X 10.9 m X 2.1 m high water level
Chlorine Feed:	Sodium hypochlorite Dosage point after the GAC filter Dosage point post-clearwell

4.0 PERFORMANCE ASSESSMENT

4.1 JULY AND AUGUST SAMPLING

Water samples were collected at the treatment plant in July and August 1996, to establish a baseline for THMs versus the level of colour and Total Organic Carbon (TOC). The samples were analyzed by Novamann. The results obtained from 5 weeks of sampling are summarized in Table 4.1. The operation data collected for the days of sampling including average daily flow, turbidity, raw water temperature and chemical dosages and residuals are presented in Table 4.2.

4.1.1 THM

It is noted from Table 4.1 that the average THM values for the treated water at the plant and in the distribution system quenched samples are 188 μg/L and 110 μg/L respectively. Due to a misunderstanding, water samples were taken at three different locations in the distribution system for the first four weeks. The samples were to be taken at the same location, in order to provide consistent THM results. The reason for the low THM result in the distribution system for Week 3 (40 μg/L) is not clear. There may have been a brief problem with low chlorine levels.

It appears however, that the results are high, and are not in compliance with the ODWO of 100 μg/L for THMs in treated water. The high formation of THM is due to the presence of organics in the water measured as Total Organic Carbon (10 mg/L). The dual media filter and the GAC filter, are under the existing conditions, inefficient at removing TOC, since the GAC filter is saturated.

4.1.2 Colour

The average colour measured during the summer sampling is 71 TCU for the raw water and 40 TCU for the treated water. The colour in the treated water is very high and does not meet the Ontario Drinking Water Objective (ODWO) of 5 TCU, the reason being that the GAC filter is saturated. Colour is classified as an aesthetic parameter and is not health related. Based on THM, colour and TOC analysis performed for Caramat Water Treatment Plant, there is no evidence of a direct relation between the level of colour or TOC in the water and the level of THM formed. The lack of THM-colour correlation is somewhat unexpected since in general the higher the colour, the higher the organic content, therefore producing higher THMs. In addition to the limited number of samples collected, other factors which may have contributed to the lack of correlation include the narrow range of colour value observed, and the analytical variability for THM analysis. The detection limit of the analytical procedures and the method reference used by Novamann is summarized in Appendix D.

The water samples taken in the distribution system for THM analysis were quenched with sodium thiosulfate to remove any chlorine residual and stop any further reaction between free chlorine and organics. Quenched water samples will maintain the same level of THM as existed at the time of sampling which is representative of what people are consuming. The water samples taken at the water treatment plant for THM analysis were not quenched, the reason being to simulate the effect of additional contact time in the distribution system versus the development of THM.

4.1.3 Turbidity

The average turbidity for the raw water is 2.7 NTU. The treated water turbidity ranges from 0.6 to 1.6 NTU. The treated water exceeds the ODWO of 1 NTU. This high level of turbidity in the treated water puts the Caramat community at risk for giardia and cryptosporidium outbreaks.

TABLE 4.1 JULY AND AUGUST SAMPLING FOR CARAMAT WATER TREATMENT PLANT WATER SAMPLES ANALYZED BY NOVAMANN

PARAMETERS	WEEK 1 (15/07/96)	WEEK 2 (24/07/96)	WEEK 3 (30/07/96)	WEEK 4 (07/08/96)	WEEK 5 (13/08/96)	MINIMUM	MAXIMUM	AVERAGE
Turbidity - Raw Water (NTU)	4.1	4.8	1.2	1.6	2	1.2	4.8	2.7
Turbidity - Treated Water (NTU)	1.6	0.7	0.6	1.4	1	0.6	1.6	1.1
Colour - Raw Water (TCU)	76.1	81.7	61.9	61.8	71.5	61.8	81.7	70.6
Colour - Treated Water (TCU)	50.5	40.2	35.2	31.2	44.8	31.2	50.5	40.4
Colour - Distribution System (TCU)	54.2	42.1	41.3	40.2	46.5	40.2	54.2	44.9
pH - Raw Water	7.39	7.93	7.47	7.66	7.38	7.38	7.93	7.57
pH - Treated Water	7.3	8.03	7.62	7.65	7.24	7.24	8.03	7.57
Alkalinity - Raw Water (mg/L - CaCO3)	57	32	37	40	35	32	57	40.2
Alkalinity - Treated Water (mg/L - CaCO3)	57	37	37	37	40	37	57	42
TOC - Raw Water (mg/L)	9.2	15.4	8.7	11.6	11.2	8.7	15.4	11.2
TOC - Treated Water (mg/L)	9.1	11.6	9.7	11.3	10.7	9.1	11.6	10.5
TOC - Distribution System (mg/L)	8.9	11.7	9.3	11.6	10.9	8.9	11.7	10.5
TTHM - Unquenched Treated Water (ug/L)	200	250	140	190	160	140	250	188
TTHM - Quenched Distribution System (ug/L) (1)	142	150	40	120	100	40	150	110

Note 1: Water samples were taken at three (3) different locations in the distribution system for the first four (4) weeks of sampling. The results for TTHM were very inconsistent.

Week 1: First Trial: 276 ug/L
Second Trial: 15 ug/L
Third Trial: 135 ug/L
Average: 142 ug/L
Week 3: Sample taken at Lot 12
Week 4: Sample taken at Lot 11

TABLE 4.2 JULY AND AUGUST SAMPLING FOR CARAMAT WATER TREATMENT PLANT OPERATION DATA COLLECTED AT THE WTP

PARAMETERS	WEEK 1 (15/07/96)	WEEK 2 (24/07/96)	WEEK 3 (30/07/96)	WEEK 4 (07/08/96)	WEEK 5 (13/08/96)	MINIMUM	MAXIMUM	AVERAGE
Average Daily Flow (m3/d)	56	56	52	52	54	52	56	54
Turbidity - Raw Water (NTU)	N/A	N/A	N/A	N/A	N/A	—	—	—
Turbidity - Treated Water (NTU)	N/A	N/A	N/A	N/A	N/A	—	—	—
Temperature - Raw Water (Degree Celsius)	14	14	16	17	18	14	18	16
Free Chlorine Residual (mg/L)	1.6	1.6	1.4	1.5	1.5	1.4	1.6	1.5
Total Chlorine Residual (mg/L)	1.8	1.8	1.6	1.8	1.7	1.6	1.8	1.7
Chlorine Dosage (mg/L)	N/A	N/A	N/A	N/A	N/A	—	—	—

N/A: Not Available

4.2 PROCESS UNIT EVALUATION

The Caramat treatment plant is not performing well. Because of the high level of colour (70 TCU) and TOC (11 mg/L) in the raw water, the capacity of the GAC filter to remove colour was exhausted after a few months of operation. It costs between $3,000 to $5,000 to replace the carbon, and this is a cost that the community can not afford.

The health concern at Caramat is not only with the level of trihalomethanes (THMs) but also with the turbidity, which is often exceeding the Ontario Drinking Water Objective.

4.2.1 Dual Media Filtration

The loading rate for the dual media filter for the maximum daily flow is evaluated as follows:

$$
\begin{aligned}
\text{Loading rate} &= \text{Maximum Day Flow} \div \text{Filter Area} \\
&= 105\ m^3/d \div (0.8\ m \times 1.2\ m) \\
&= 109\ m/d \text{ or } 4.6\ m/h
\end{aligned}
$$

The MOEE Guidelines for the maximum filtration rate allowed for small systems is 9 m/h. The filtration rate for Caramat Water Treatment Plant is considerably lower than the criteria recommended for the maximum day flow. However, this filtration rate criteria normally applies when filtration is preceded by chemical addition and settling (conventional treatment), or direct filtration. The treatment process used for Caramat Water Treatment Plant involve filtration alone, without addition of any chemical but chlorine for post-disinfection.

4.2.2 GAC Contactor

The loading rate for the GAC filter for the maximum daily flow is evaluated as follows:

Loading rate	= Maximum Day Flow ÷ Filter Area
	= 105 m^3/d ÷ (1.4 m X 1.2 m)
	= 62.5 m/d or 2.6 m/h
Height	= 1.5 m (estimated)
Empty Bed Contact Time	= Bed Volume ÷ 105 m^3/d X 24 h/d X 60 min/h
	= (1.4 X 1.2 X 1.5) ÷105 m^3/d X 24 X 60
	= 35 min.

This is a substantial contact time for carbon however, the high concentration of organics in the raw water and the ineffectiveness of the dual media filter without coagulation causes the carbon to become saturated in a few months.

4.2.3 Disinfection

Disinfection of drinking water is the most important aspect of the treatment process. Harmful organisms in water such as bacteria, viruses or cysts can cause illness ranging from minor intestinal disorders to potentially fatal infections. Maintaining an effective disinfection system must be the overriding priority of the plant operations. For surface waters, chlorination with a 'free' residual is the most common and most practical method of disinfection. To be effective, the treated water must be very low in turbidity as suspended particles can shield bacteria and virus from the effect of chlorine. Even turbidity levels greater than 0.1 NTU can indicate a greater probability of chlorine-resistant cysts being present.

To achieve a safe level of disinfection, it is necessary to dose the treated water with a sufficient amount of chlorine to produce a 'free' residual, and to give the chlorine sufficient time to inactivate the potentially harmful organisms. This is called the concentration-time factor or CT, also referred to as the primary disinfection stage. Sufficient CT must be achieved at the treatment plant before the first service connection. Current MOEE guidelines call for a minimum residual of 0.5 mg/L for a minimum contact time of 30 minutes after filtration. This

disinfection guideline for water treatment plants in Ontario is under review, and the new guideline may be similar to the Surface Water Treatment Rule (SWTR) promulgated by U.S. Environmental Protection Agency (U.S. EPA). The SWTR established CTs value for chlorine, chlorine dioxide, ozone and chloramines required to achieve adequate inactivation of giardia cysts and viruses. For the purpose of calculating CT value, T is the time (in minutes) it takes the water, during peak plant flows, to move between the point of disinfectant application and a point where, C, residual disinfectant (in mg/L) concentration is measured just prior to the first customer. The calculation must take into account the degree of short circuiting in the storage tank.

For free residual chlorination, the CT required is based on the inactivation of giardia cysts in cold water. Cysts are harder to inactivate by free chlorine than viruses, therefore, it is implied that proper inactivation of giardia cysts will ensure inactivation of viruses. Disinfection is not effective for the inactivation of cryptosporidium therefore, it is necessary to perform adequate filtration at the water treatment plant for any municipality with a risk of cryptosporidium outbreaks.

Secondary disinfection refers to the maintenance of a residual in the distribution system to protect against bacterial re-growth or minor cross connection contamination. This maintenance residual is commonly achieved with 'free' chlorine, but alternatively can be converted to chloramine or 'combined' residual with the addition of ammonia. Chloramines have the advantage of being more stable and lasting much longer in the system. They also do not react with organics to form THMs. They are however much less effective as a disinfectant and are very weak in inactivating viruses and cysts. Use of chloramine as a primary disinfectant is therefore not recommended.

The MOEE guidelines recommend a minimum free chlorine residual of 0.2 mg/L at the end of the distribution system. The AWWA recommends a residual of 1.0 mg/L of chloramine be maintained to prevent re-growth (AWWA, 1993). These chlorine residuals do not take into consideration water characteristics such as temperature and pH that affect disinfection efficiency.

According to the SWTR, all community and noncommunity public water systems which use a surface water source or ground water under the direct influence of a surface water must achieve a minimum of 99.9 percent (3-log) removal and/or inactivation of giardia cysts. According to these guidelines, systems with sewage and agricultural discharges to the source water should provide treatment to achieve an overall 5-log removal/inactivation of Giardia cysts, while the minimum required 3-log removal/inactivation is sufficient for sources with no significant microbiological contamination from human activities, a 4-log removal/inactivation of cysts should be provided for source waters whose level of microbiological contamination is between these two extremes.

There are no agricultural activities in the Caramat area. However, the presence of on-site sewage systems around Caramat Lake indicates a potential for bacteriological contamination. It is advised to verify the disinfection requirement for a 4-log removal/inactivation of giardia cysts. Well operated direct filtration plants which have been optimized for turbidity removal can be expected to achieve at least a 2.0-log removal of giardia cysts. However, no credit will be allocated for removal of cysts for the Caramat plant, since there is no coagulant dosage performed before the filters. The required CT will be based on 4.0-log inactivation of giardia cysts.

Examples of CT calculations for winter and summer conditions are presented in Appendix C. The contact time (T) in the clearwell is estimated by using the maximum daily flow for the winter and the summer under the worst condition, where the reservoir is half full. This should reflect the situation at the water treatment plant where the filters are producing the maximum

daily flow, and the high lift pumps are pumping at peak hourly rate to the distribution system.

Based on the "Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Source" (U.S. EPA, 1990), the baffle condition in the clearwell qualified as T_{10}/T factor can be evaluated to estimate the effective contact time in the clearwell. This factor represents the ratio between T_{10}, which is the time it takes 10 percent of a dye or tracer to be detected at the basin outlet after it is injected into the basin influent flow, and the theoretical detention time for plug flow in pipelines and flow in a completely mix chamber.

When tracer studies are not available, a description of the clearwell and baffling condition can be used to estimate the T_{10}/T factor. The clearwell for Caramat treatment plant has no baffles, and is described as poor baffling condition. Therefore, the T_{10}/T factor is 0.3.

The results of the evaluation of residual chlorine concentration required for inactivation of giardia cysts under various conditions (Appendix C.1 and C.2) are summarized in Table 4.3.

TABLE 4.3 Calculation of minimum residual chlorine concentration necessary for inactivation of giardia cysts

CONDITIONS	**Free Residual Chlorine Concentration (mg/L) C**	**Contact Time (minutes) T**
Winter condition with the clearwell 1/2 full	0.76	323
Summer condition with the clearwell 1/2 full	0.21	292

The maximum CT values provided in the Tables E-1 from the Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems using Surface Water Sources (USEPA, 1990), are for 3-log inactivation. Therefore, only calculations for 3-log inactivation could be performed. Due to the proximity of the community to the lake and presence of on-site sewage systems it would be appropriate to consider higher removals for giardia i.e. 4-log (99.99%) removal, leading to higher free chlorine residual than the concentrations presented in Table 4.3.

The results presented in Table 4.3 show that a higher chlorine residual is required during the winter since lower water temperature reduces the rate of inactivation. Information collected from the water plant shows that the total chlorine residual is normally maintained between 1.4 to 1.6 mg/L. This residual should be sufficient to provide adequate inactivation of giardia cysts. It is noted that a lower chlorine residual of 1 mg/L may be desirable during the summer. This would reduce the formation of THM, provided that a residual can be maintained throughout the system.

5.0 CONCLUSIONS

Based on July and August 1996 sampling, the average THM values for the treated water at the plant and in the distribution system are 188 μg/L and 110 μg/L respectively. These results are high and are not in compliance with the ODWO of 100 μg/L for THMs in treated water. The high formation of THM is due to the presence of organics in the water.

Information collected from the water plant shows that the total chlorine residual is normally maintained between 1.4 to 1.6 mg/L, which should be sufficient to provide adequate inactivation of giardia cysts. Chlorine is not effective for cryptosporidium.

The turbidity of the treated water ranges form 0.6 to 1.6 NTU with an average of 1.1 NTU. This is higher than the 1 NTU ODWO for turbidity. Disease outbreaks caused by giardia and cryptosporidium have been reported with increased frequency over the last decade in Canada. These protozoan parasites (especially cryptosporidium) are more difficult to kill with disinfectants, and therefore their removal by physical processes is vital. Current US research and experience now indicates that a turbidity of 0.1 NTU in filter effluent is needed to provide protection from cryptosporidium. This would be very difficult to obtain when using filtration alone without preceding it by chemical injection and settling.

The Caramat Water Treatment Plant is producing a water that is disinfected from a bacteriological standpoint however, it significantly exceeds the new THM guideline and frequently exceeds the turbidity guideline. The elevated turbidity indicates that cyst-sized particles pass into the system. This represents a health risk that cannot be readily corrected without the addition of full treatment. Similarly, to reduce the formation of THMs it is necessary to remove much of the organic material from the water prior to disinfection. The activated carbon process as installed will accomplish this when the carbon is 'fresh' however, the bed life is short so the replacement cost is prohibitive. However, the frequent replacement of the GAC filter would not be sufficient to meet the MOEE guidelines, since the existing process would not provide particle removal and produce a turbidity in the treated water of 1.0 NTU. Aluminum residual in the treated water is not an issue since the plant does not use any coagulant.

6.0 RECOMMENDATIONS

Given the limited processes and allocated hours of operation, there is little that can be done quickly or inexpensively to improve the Caramat water quality. The amount of plant upgrading that would be needed is beyond the scope of this project. In addition, upgraded facilities would require more operator time commitment and significantly increased chemical costs. The municipality would need to commit to these additional operating costs prior to an up-grading of the plant.

6.1 ALTERNATIVES FOR UP-GRADING THE PLANT

The existing filter unit is suitable for reuse with the addition of a rapid mix, flocculation tank and a clarifier. There would also need to be chemical feed systems for the primary coagulant, a coagulant aid and pH adjustment. There is an existing concrete tank in the existing building that was part of the original treatment system. It is currently unused however, it was full of water and appeared to be sound. This tankage could be used in the plant up-grade. It is noted that the GAC filter would not be required to meet ODWO for a full conventional treatment plant.

Chloramination is not a solution to the THM formation at this plant because as a primary disinfectant and in the absence of full treatment, contact time would be excessive. As a secondary disinfectant there would be no benefit as the THMs are already formed in the clearwell.

Options for up-grading the plant include:

OPTION 1: ADDITION OF NEW PRE-TREATMENT UNIT

1. A new pre-treatment module consisting of an in-line static mixer, a flocculation tank, and a clarifier could be installed in an addition to the building next to the filter wall.
2. New chemical feed equipment could be installed in the existing building although there may be a lack of space for chemical storage.
3. The existing concrete tankage could be reconfigured for wastewater treatment.

OPTION 2: REHABILITATION OF EXISTING CONCRETE UNIT

1. The existing concrete treatment basin consists of a mixing/flocculation chamber followed by a clarifier with tube settlers. The tank was full of water at the time of the on-site inspection and appeared to be sound. It was not possible however to determine the condition of the flocculator motor. This treatment basin could be cleaned and refitted as required and would be suitable for the new pre-treatment.
2. New chemical feed equipment could be installed in the existing building although there may be a lack of space for chemical storage
3. A wastewater settling tank could be buried outside the building for settling of the clarifier blow down and the filter washwater.

6.2 COST ESTIMATES

Cost estimates for the proposed modifications are presented in Table 6.1.

Capital Cost Estimates

OPTION 1: Addition Of New Pre-Treatment Unit	**\$123,410 (Taxes not included)**
OPTION 2: Rehabilitation Of Existing Concrete Unit	**\$ 90,000 (Taxes not included)**

Annual Operation Costs for Options 1 and 2

OPTION 1 and OPTION 2	**\$31,050 (Taxes not included)**

Amortization over 20 years including Capital and Operation Costs

OPTION 1: Addition Of New Pre-Treatment Unit	**\$440 per year per household (\$37 per month per household)**
OPTION 2: Rehabilitation Of Existing Concrete Unit	**\$400 per year per household (\$34 per month per household)**

TABLE 6-1

CARAMAT UP-GRADE PRELIMINARY ESTIMATE 21-Feb-97

OPTION 1: NEW PRE-TREATMENT UNIT

ADDITION OF 1 CLARIFIER	1	$	30,000	each	$	30,000
REHABILITATION OF TANKS FOR WASTEWATER					$	10,000
CHEMICAL FEEDS	3	$	8,000	each	$	24,000
BUILDING RENOVATION TO SUIT EXPANDED PLANTS					$	30,000
		Sub Total			**$**	**94,000**
	CONTINGENCY			10%	**$**	**9,400**
	ENGINEERING			15%	**$**	**20,010**
	TOTAL UP-GRADE COST:				**$**	**123,410**

ANNUAL OPERATION COST

STAFF (1 operator, 2 h/d, 7d/week @ $18/h)	$	13,000	
CHEMICAL (Coagulant, Coagulant aid, Pre-alk. adj., Post pH adj., Chlorine)	$	8,850	
ANALYTICAL TESTING REQUIREMENT	$	3,000	
POWER	$	1,200	
MAINTENANCE	$	5,000	
TOTAL OPERATING:	**$**	**31,050**	/year

OPTION 2: UP-GRADE EXISTING TREATMENT PLANT

UP-GRADE OF EXISTING TANKS FOR USE AS CLARIFIER					$	20,000
CHEMICAL FEEDS	3	$	8,000	each	$	24,000
WASTEWATER TREATMENT TANK *					$	15,000
BUILDING RENOVATION TO SUIT EXPANDED PLANTS					$	10,000
		Sub Total			**$**	**69,000**
	CONTINGENCY			10%	**$**	**6,900**
	ENGINEERING			15%	**$**	**14,100**
	TOTAL UP-GRADE COST:				**$**	**90,000**

* The possibility to use Dunn Lake for wastewater discharge to reduce the sub tot. cost by $15,000 shall be investigated.

ANNUAL OPERATION COST

STAFF (1 operator, 2 h/d, 7d/week @ $18/h)	$	13,000	
CHEMICAL (Coagulant, Coagulant aid, Pre-alk. adj., Post pH adj., Chlorine)	$	8,850	
ANALYTICAL TESTING REQUIREMENT	$	3,000	
POWER	$	1,200	
MAINTENANCE	$	5,000	
TOTAL OPERATING:	**$**	**31,050**	/year

GLOSSARY AND LIST OF ABBREVIATIONS

Alum	: aluminum sulphate
CT	: Value required to achieve adequate inactivation and/or removal of cysts and viruses. T is the time (in minutes) it takes the water during peak hourly flow, to move between the point of disinfectant and a point where C, the residual disinfectant concentration (mg/L), is measured prior to the first customer.
d	: day
°C	: degree Celsius
DWSP	: Drinking Water Surveillance Program
ECR reagent	: Eriochrome Cyanine R
FID	: Flame Ionization Detector
ft	: foot
G	: flocculation energy gradient
Gt	: flocculation energy
GC/MS	: Gas Chromatograph / Mass Spectrometry
GAC	: Granular Activated Carbon
g	: gram
h	: hour
HFS	: hydroxylated ferric sulphate (Ferriclear)
ICP	: Inductively Coupled Plasma Atomic Emission Spectoscopy
IG	: imperial gallon
kW	: kilowatt
L	: litre
L/cap.d	: litres per capita per day
L/s	: litres per second
m	: metre
m^2	: square metres
m^3	: cubic metres

m^3/d	: cubic metres per day
m/h	: metres per hour (equivalent $m^3/m^2.h$ - filtration rate)
µg/L	: micrograms per litre
mg/L	: milligrams per litre
mm	: millimetre
mL/min	: millilitres per minute
min	: minute
NTU	: Nephelometric Turbidity Unit
OCWA	: Ontario Clean Water Agency
ODWO	: Ontario Drinking Water Objective
%	: percent
PACL	: polyaluminum chloride
PVC	: polyvinyl chloride
lb	: pound
rpm	: revolution per minute
SOR	: Surface Overflow Rate
SWTR	: Surface Water Treatment Rule
T_{10}/T	: This factor describes the baffling condition in the clearwell, and represents the ratio between T_{10}, which is the time it takes 10 percent of a dye or tracer to be detected at the basin outlet after it is injected into the basin influent flow, and the theoretical detention time for plug flow in pipelines and flow in a completely mixed chamber.
TOC	: Total Organic Carbon
THMs	: Trihalomethanes
TCU	: True Colour Unit
W/V	: weight/volume

REFERENCES

American Water Works Association Research Foundation - Optimizing Chloramine Treatment, 1993.

Environmental Science and Engineering Magazine. Drinking water Update - The Facts About Human Health and Aluminum in Drinking Water, January, 1997.

U.S. Environmental Protection Agency, Science and Technology Branch Criteria and Standards Division of Drinking Water. Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources, October , 1990.

Ontario Ministry of the Environment, Environmental Approvals and Land Use Planning Branch. Guidelines for the Design of Water Treatment Works, April 1982.

APPENDICES

Plant Survey

Appendix A

PLANT Shipping Address: Tel: (807) 872-2545	**Caramat** P.O. Box 25 Caramat, Ont. P0T 1J0	 Fax: (807) 872-2664
PREPARED BY:	**R.A. LeCraw, P.Eng.**	**DATE: Plant Visit June 18, 1996**

STAFF:

Superintendent: Oiva Laatu

No. of Operators: 1

Names of Operators:

Hours of Operation with Staff: 1h/d

Certified Y/N: N

PLANT CAPACITY:

Average Daily Flow:	75 m^3/d (52 L/min)
Maximum Daily Flow:	105 m^3/d (73 L/min)
Rated Plant Capacity:	95 m^3/d (66 L/min)
Population Served:	250 +/-

OPERATING AUTHORITY:
Caramat

YEAR OF CONSTRUCTION: Original ???
Up-Grade 1994

SOURCE OF RAW WATER: Caramat Lake

RAW WATER CHARACTERISTICS:

- Colour: 40 - 70 TCU
- Turbidity: 1 - 5 NTU
- pH: 7.4 - 7.9
- Alkalinity: 30 - 57 mg/L - $CaCO_3$
- THM: -

CHEMICALS:

- Coagulant: None
- Coagulant Aid: None
- Alkalinity/pH Adjustment:None
- Disinfection: Type: Sodium Hypochlorite
  Dosage: ??? mg/L
  Injection Point: Post only, after filters and after clearwell

ANALYSIS DONE ON-SITE:
Turbidity
Chlorine residual

LAB EQUIPMENT AVAILABLE:
Hach 1720C Turbidimeter on-line
Chlorine analyzer:

PROCESS CONFIGURATION:

CHEMICALS METERING:

	TYPE	CAPACITY	CONTROL	CONDITION
Coagulant:	None			
Coagulant Aid:	None			
• Alkalinity /pH Adjustment:	None			
• Disinfection:				
	Sodium Hypo-chlorite		Manual control Only	Fair. No Standby.
• Other:				

PROCESS CONFIGURATION (Continued):

INTAKE:	TYPE				CONDITION	NOTES
SCREENING:	TYPE	NO	DIMENSIONS		CONDITION	NOTES
LOW LIFT PUMPS:	TYPE	NO		CAPACITY	CONDITION	NOTES
		I		66 L/min		
HIGH LIFT PUMPS:	TYPE	NO		CAPACITY	CONDITION	NOTES
		I		360 L/min		
MIXING/FIOCCU.:	TYPE				CONDITION	NOTES
	None					
CLARIFICATION:	TYPE	NO	DIMENSIONS	VOLUME	CONDITION	NOTES
	None					
SAND FILTER:	TYPE	NO	DIMENSIONS	HYDRO. LOADING	AREA	NOTES
Napier Reid two compartments			0.8 m X 1.2 m	3.72 m/h	0.96 m^2	
	Dual media sand/anthracite			(1.55 $USGPM/ft^2$)	(10.3 ft^2)	
GAC FILTER:	TYPE	NO	DIMENSIONS	HYDRO. LOADING	AREA	NOTES
Napier Reid two compartments			1.4 m X 1.2 m	2.2 m/h	1.68 m^2	
	GAC contactor			(0.88 $USGPM/ft^2$)	(18.1 ft^2)	
CLEARWELL:		NO	DIMENSIONS	VOLUME	BAFFLED:	NOTES
		1	6.2 m X 10.9 m	142 m^3	No	High level 2.1 m Low level 1.93 m

PLANT CONTROL:

- Flow (Manual Set/Auto): Manually set by low lift pump selection & manual throttling of raw water flow
- Level: Level control on low lift pumps from clearwell
- On/Off:

PROCESS MONITORING:

	INSTRUMENT	MONITORING FREQUENCY	LOCATION	NOTES
• Turbidity:	On-line Hach 1720C Turbidimeter	Continuous	Raw and filtered	
• pH:				
• Free Chlorine Residual:	Lab monitoring	Daily	Raw and filtered	
• Total Chlorine Residual:				
• Temperature:				
• Aluminum Residual:	MOEE testing only			
• Colour:				
• Other:				

ISSUES:

Moderate colour low turbidity water. GAC filter expired after three months and has not been replaced. High THM from high organics and high free chlorine residuals.

CHECK LIST:

- Copy of Certificate of Approval. On-file
- Copy of DWSP report if available. N/A
- Copy of monthly flows for the previous year. N/A
- Copy of the monthly analysis for the previous year to evaluate plant performance for the raw water, settled water and plant effluent. OK

  Analysis of interest are: DOC, true colour, turbidity, pH, alkalinity, chlorine residual, temperature and THM.

Certificate of Approval

Appendix B

Ministry of the Environment and Energy
Ministère de l'Environnement et de l'Énergie
Ontario

APPROVALS BRANCH
3rd Floor
Tel. (416) 440-3722
Fax. (416) 440-6973

250 Davisville Avenue
Toronto, Ontario
M4S 1H2

250, avenue Davisville
Toronto (Ontario)
M4S 1H2

December 21, 1993

Caramat Local Services Board
P.O. Box 25
Caramat, Ontario
P0T 1J0

Dear Sirs:

Re: Caramat Local Services Board
Well Water Supply System
Certificate of Approval No. 7-0996-93-006

Enclosed herewith is the Ministry's Certificate of Approval No. 7-0996-93-006 for approval of Phase 1 modifications to the existing unapproved Caramat water supply system.

It should be noted that even with these new treatment works, the existing surface water treatment plant may not ensure that the drinking water meets the current Ontario Drinking Water Objectives with respect to colour levels, on a continuous basis, especially during the late winter and early spring. Proctor & Redfern Limited has confirmed that it is anticipated that the existing surface water supply will be replaced by well supplies in the near future.

Copies of this advisory letter and the attached Certificate are being forwarded to the persons indicated.

Yours truly,

W. Gregson, P. Eng.
Director
Sections 52 & 53,
Ontario Water Resources Act

JC/fn
Encls.
cc: District Manager - MOEE Thunder Bay
Mr. V.A. Masemann, P. Eng., Proctor & Redfern Limited
Director, Water Resources Branch, Attn: K. Roberts

Ministry of Environment and Energy
Ministère de l'Environnement et de l'Énergie
Ontario

Caramat Local Services Board
P.O. Box 25
Caramat, Ontario
P0T 1J0

You have applied in accordance with Section 52 of the Ontario Water Resources Act for approval of:

Phase 1 modifications to the existing Caramat Water Supply system located on the south shore of Caramat Lake, north of Tamarac Street, in the District of Thunder Bay including:

WATER PUMPHOUSE

- replacement of the existing low lift pump with instock water pump throttled to a discharge rate of 1.1 L/s to match the filter rate;
- replacement of the existing filter with a two stage gravity filter, first stage with silica sand and anthracite, second stage with granular activated carbon with a filtration rate of 1.1 L/s and a backwash rate of 8.7 L/s;
- replacement of the existing high lift pump with instock water pump having a rated capacity of 6.0 L/s;
- three (3) chlorine feed pumps (one for adding chlorine to the treated water prior to the clearwell, one for topping up the treated water as it leaves the pumphouse and one as standby);
- flow metering and recording equipment;
- raw and treated water sampling taps;
- continuous chlorine residual analyzer and recorder;
- continuous turbidity monitoring and recording equipment;
- miscellaneous electrical, lighting and ventilation work;
- a portable 5 kW diesel generator set;

together with associated piping and valves and security features;

all of the above in accordance with the plans and reports prepared by the Proctor & Redfern Limited, Consulting Engineers.

You are hereby notified that this approval is issued subject to the following terms and conditions outlined below:

TERMS AND CONDITIONS

1. For the purpose of this Certificate of Approval:

    a. "the Director" means any Ministry employee appointed by the Minister pursuant to Section 5 of the Ontario Water Resources Act;

    b. "the Regional Director" means the Regional Director of the Northern Region of the Ministry of Environment and Energy;

    c. "the District Manager" means the District Manager of the Thunder Bay District Office of the Ministry of Environment and Energy's Northern Region;

    d. "the Owner" means Caramat Local Services Board and includes its successors and assignees such as the Operating Authority;

    e. "works" means the facility described in the Owner's application, the Certificate and in the supporting documentation referred to herein, to the extent approved by this Certificate;

    f. "the water supply and treatment system" means the works and auxiliaries for collection, treatment, storage and distribution of the water from the source of supply to free flowing outlet of the ultimate consumer;

    g. "Maximum Acceptable Concentration" means a limit applied to concentrations of substances in the drinking water above which there are known or suspected adverse health effects;

    h. "quarterly sampling" means sampling conducted on any such day within each consecutive three-month period that the time interval between consecutive quarterly sampling events is not less than 45 days.

2. The requirements of this Certificate of Approval are imposed pursuant to Section 52 of the Ontario Water Resources Act.

    The issuance of this Certificate in no way abrogates the Owner's legal obligations to take all reasonable steps to avoid violating other applicable provisions of this legislation and other legislations and regulations.

3. a. The requirements of this Certificate are severable. If any requirement of this Certificate, or the application of any requirement of this Certificate to any circumstances, is held invalid, the application of such requirement to other circumstances and the remainder of this Certificate shall not be affected thereby.

b. In all matters requiring the interpretation and implementation of this Certificate, the conditions of the Certificate shall take precedence, followed in descending order by the Owner's application and the documentation, referred to in this Certificate, which is submitted in support of the application.

4. The Owner must ensure compliance with all the terms and conditions of this Certificate. Non-compliance constitutes a violation of the Ontario Water Resources Act and is grounds for enforcement.

5. The Owner shall, forthwith upon the request of the Director, Regional Director or District Manager, furnish any information requested concerning compliance with this Certificate including any records required to be kept by this Certificate.

6. The Owner shall notify the Regional Director in writing of any of the following changes within thirty (30) days of the change occurring:

   a. change of Owner or operating authority or both;
   b. change of address or address of the new Owner.

7. a. The Owner shall prepare and make available for inspection by Ministry personnel upon request, a complete set of drawings within one (1) year of substantial completion of the water works which drawings shall show the water works as constructed at that time.

   b. A complete set of the "as constructed" drawings, incorporating any amendments made from time to time, shall be kept by the Owner at the administration building of the water works as long as the water works are kept in operation.

<u>OPERATIONS AND MAINTENANCE</u>

8. a. The Owner shall endeavour to take all necessary steps, within his authority, to ensure protection of the source of water supply (ground water aquifer) from contamination.

   b. Subsequent to construction of, or repairs to the works, and prior to utilization of the works for the supply of potable water, the Owner shall ensure that the works have been adequately disinfected.

   c. The Owner shall ensure that, at all times, the water works and related equipment and appurtenances which are installed or used to achieve compliance with this Certificate are properly operated and maintained. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, adequate laboratory and process controls, and the use of process chemicals and other substances that come in contact with water being treated, that are suitable for the process, compatible with each other and appropriate for drinking water.

d. Further to subsection (c), the Owner shall ensure that all chemicals used in the treatment process are "Food Grade" and meet the National Sanitation Foundation Standard 60 or American Water Works Association Standards for drinking water treatment chemicals.

e. The Owner shall ensure that prior to commissioning of the water works, contingency plans and procedures are established and adequate equipment and material are available for dealing with emergencies, upset conditions and equipment breakdowns in the water works.

f. The Owner shall establish notification procedures to be used to contact the District Manager and other relevant authorities in the case of any emergency situation.

g. The Owner shall prepare an operations and maintenance manual within three (3) months of date of this Certificate of Approval and keep it up to date and, upon request, shall make the manual available for inspection by Ministry personnel and shall, upon request, furnish a copy of the manual to the Ministry.

h. The Owner shall establish procedures for receiving and responding to complaints, including a system for recording steps taken to determine the cause of each complaint and measures taken to alleviate the cause and prevent its recurrence.

PERFORMANCE

9. The Owner shall design, construct and, subject to condition no. 14, operate the entire water supply and treatment system in such a manner, and with such facilities that water supplied to the consumers serviced by the system satisfies the water quality objectives, guidelines and requirements as set out in the publication entitled "Ontario Drinking Water Objectives" 1983, as amended from time to time by more recently published editions, with the exception of colour where it must comply within eighteen (18) months of the date of this Certificate of Approval or a variance is in place.

10. a. The water treatment plant has been designed and approved to treat water at a maximum flow rate of $75.2m^3/d$ (total).

b. For the purpose of this Certificate and Subsection 107(3) of the Ontario Water Resources Act, the introduction of flows into the water treatment plant in excess of the maximum flow rate shown in subsection (a) above is not approved under this Certificate except:

i. where necessary, to meet an unusual water demand for fighting a conflagration; or

ii. where necessary for the purpose of maintenance of the water works, essential to their efficient operation, provided that the quality requirements for the treated water will be satisfied.

c. The Owner shall record the time and duration of each event of flow rate in excess of that specified in subsection (a) of this condition along with the reasons for it.

11. a. The Owner shall construct and operate the disinfection system in such a manner and with such facilities that a minimum of 0.5 mg/L of total chlorine residual in the treated water after minimum 15 minutes contact time, and before the first consumer, is maintained at all times.

b. The Owner shall notify the District Manager and the Medical Officer of Health forthwith in the event that unchlorinated water is directed to the distribution system.

12. The Owner shall use best efforts to construct and operate the backwash treatment facilities in such a manner that within 18 months of the dated of this Certificate of Approval, the concentration of 15 mg/L suspended solids is not exceeded in the backwash water discharged to Duran Lake.

MONITORING AND REPORTING

13. a. The Owner shall install, maintain and operate a sufficient number of flow measuring devices, calibrated at regular intervals not exceeding one year to ensure their accuracy to within plus or minus 5% of the full scale reading of the measuring devices, in order to measure:

i. the flow rate of water being conveyed to and through the water treatment plant (raw water);

ii. the daily quantity of treated water supplied to the distribution system.

b. The data generated in accordance with subsection (a) above shall be deemed to be conclusive of the minimum flow rates for the purposes of determining compliance with and enforcement of this Certificate.

c. The Owner shall install, maintain and operate continuous water quality analyzers and indicators with alarm systems, calibrated at regular intervals not exceeding three months, in order to measure:

i. free chlorine residual in treated water;
ii. filtered water turbidity in treated water;

14. The Owner shall ensure that the following monitoring program is carried out:

   a. Sampling locations shall be established to the satisfaction of the District Manager prior to commencement of operation of the works. Sampling locations may only be changed or abandoned and new locations added following commencement of operation if, in the opinion of the District Manager, it is necessary to do so to ensure representative samples are being collected.

   b. Samples of raw water and treated water shall be collected and analyzed for at least the following parameters at the indicated frequency:

RAW WATER

Quarterly	Weekly
Alkalinity	Total Coliform
Hardness	Fecal Coliform
Calcium	
Sodium	
Iron	
Copper	
Lead	
Zinc	
Arsenic	
Aluminum	
Manganese	
Conductivity	
Chloride	
Sulphate	
Ammonia + Ammonium (N)	
Total Kjeldahl Nitrogen	
Nitrite	
Nitrate	
Dissolved Organic Carbon	
Phenols	
pH	
Turbidity	
Colour	

In addition to the above routine sampling program, on-site testing should be performed and results recorded, at the minimum frequency of once a day, for the following water parameters:

- pH, Colour, Turbidity, Temperature

TREATED WATER

Quarterly	Weekly
Alkalinity	Total Coliform
Hardness	Fecal Coliform
Calcium	Standard Plate Count
Sodium	
Iron	
Copper	
Lead	
Zinc	
Arsenic	
Aluminum	
Manganese	
Conductivity	
Chloride	
Sulphate	
Ammonia + Ammonium (N)	
Total Kjeldahl Nitrogen	
Nitrite	
Nitrate	
Dissolved Organic Carbon	
Total Trihalomethanes	
pH	
Turbidity	
Colour	

In addition to the above routine sampling program, on-site testing should be performed and results recorded, at the minimum frequency of twice a day, for the following treated water parameters:

- pH, Colour, Turbidity, Temperature, Free Chlorine Residual, Total Chlorine Residual

DISTRIBUTION SYSTEM

Quarterly	Weekly
Alkalinity	Total Coliform
Hardness	Fecal Coliform
Calcium	Standard Plate Count
Sodium	
Iron	
Copper	
Lead	
Zinc	
Arsenic	
Aluminum	
Manganese	
Conductivity	

DISTRIBUTION SYSTEM

Quarterly	Weekly
Chloride	
Sulphate	
Ammonia + Ammonium (N)	
Total Kjeldahl Nitrogen	
Nitrite	
Nitrate	
Dissolved Organic Carbon	
Total Trihalomethanes	
Colour	

NOTE: The minimum number of bacteriological samples to be collected from different locations of sampling points shall be as outlined in the "Ontario Drinking Water Objectives" 1983, as amended from time to time by more recently published editions.

c. Samples of discharge of the backwash water shall be collected and analyzed for at least the following parameters at the indicated frequency:

Parameter:	Suspended Solids
Type of Sample:	Composite*
Frequency:	Monthly

* Composite sample means a sample collected over the discharge period. The sample shall be made up of at least three (3) discreet samples taken at equal time intervals.

d. The sampling and analyses required by subsections (b) and (c) of this condition shall be performed in accordance with the "Guide to the Collection and Submission of Samples for Laboratory Analysis", Ministry of the Environment, 1985, and the "Handbook of Analytical Methods for Environmental Samples", Ministry of the Environment, 1983, or as described in Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989, as amended from time to time by more recently published editions.

e. The Owner shall submit the analytical results obtained pursuant to this condition to the District Manager within thirty (30) days of collection of the samples or within such longer period of time as the District Manager may agree.

f. Following review of any of the analytical results or any of the reports required by condition No. 15 of this Certificate, the District Manager may alter the frequencies and locations of sampling and parameters for analysis required by this condition if he/she considers it necessary for proper assessment of the quality of supplied water or if he/she is requested to do so by the Owner and considers it acceptable by the evidence of information submitted in support of the request.

g. If the Owner monitors any of the parameters required by subsection (b) of this condition, at locations designated for this purpose by the District Manager and in accordance with subsection (d), more frequently than it is required by this condition, the analytical results of all such samples, both required and additional, shall be included in reporting of the values required by this Certificate, and the increased frequency, or all dates of sampling, shall also be specified in the reports.

h. Notwithstanding subsection (e) of this condition, the Owner shall notify the District Manager and the Medical Manager of Health forthwith if any analytical result exceeds any Maximum Acceptable Concentration of a health-related parameter, or shows unsafe bacteriological water quality, or shows confirmed bacteriological water quality, as defined in the publication entitled "Ontario Drinking Water Objectives" 1983, as amended from time to time by more recently published editions.

15. The Owner shall prepare and submit a performance report to the District Manager on an annual basis. The first such report shall cover the period from the commencement of operation of the water works to the end of the calendar year and shall be submitted within sixty (60) days following such reporting period. Each subsequent report shall be submitted within sixty (60) days of the completion of the calendar year being reported upon. The reports shall contain, but need not be limited to, the following information in a format acceptable to the District Manager:

a. a summary and discussion of the quantity of water supplied during the reporting period compared to the design values for the population serviced, including peak flow rates, maximum daily and monthly average flows;

b. a summary and interpretation of analytical results obtained in accordance with condition No. 14 of this Certificate of Approval;

c. a tabulation and description of any emergency or upset conditions which occurred during the period being reported upon;

d. a summary of the chemicals used in treatment processes with special reference to any abnormal usages.

The reasons for the imposition of these terms and conditions are as follows:

1. Condition No. 1 is included to define terms used in this Certificate of Approval.

2. Condition No. 2 is included to emphasize that the issuance of the Certificate does not diminish any other statutory and regulatory obligation to which the Owner is subject in the construction, maintenance and operation of the works.

3. Condition No. 3 is included to clarify how the Certificate is to be judicially interpreted and specifically, to clarify that the requirements of the Certificate are severable and that they prevail over supporting documentation.

4. Condition No. 4 is included to emphasize that the Owner is under a statutory obligation to ensure compliance with the Certificate.

5. Condition No. 5 is included to ensure that Ministry personnel, when acting in the course of their duties, will be given unobstructed access to the facilities, information and records related to the works which are the subject of this Certificate, to enable the Ministry to be assured of the Owner's compliance with the terms and conditions of this Certificate.

6. Condition Nos. 6 and 7 are included to ensure that the Ministry records can be kept accurate and current with respect to approved works and to ensure that subsequent owners of the works are made aware of the Certificate and continue to operate the works in compliance with it.

7. Condition No. 8 is included to ensure that the works will be operated, maintained, funded, staffed and equipped in a manner enabling compliance with the terms and conditions of this Certificate and that the Owner can deal with contingency and/or emergency situations.

8. Condition Nos. 9 and 11 are included to ensure that the water quality delivered by the treatment plant satisfies the current "Ontario Drinking Water Objectives" in order to protect public health and to ensure that the water is aesthetically acceptable.

9. Condition No. 10 is included to ensure that the peak flow rate of water through the works is within the approved treatment capacity of the works.

10. Condition No. 12 is imposed to set out the maximum concentration of suspended solids which is allowed in the discharge to the receiving water body. This limit is established to minimize the environmental impact to the receiver.

11. Condition Nos. 13, 14 and 15 are related to the flow metering, sampling and monitoring program and performance report are being imposed to ensure that all pertinent data are available for the water works performance evaluation and to ensure that the water works is operated and maintained at the level consistent with the design objectives, and is effective in producing water of an acceptable quality at all times.

You may by written notice served upon me and the Environmental Appeal Board within 15 days after receipt of this Notice, require a hearing by the Board. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, Chapter 0.40, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the water works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary,
Environmental Appeal Board,
112 St. Clair Avenue West,
Suite 502,
Toronto, Ontario.
M4V 1N3

AND

The Director,
Section 52, Ontario Water Resources Act,
Ministry of Environment and Energy,
250 Davisville Avenue, 3rd Floor,
Toronto, Ontario.
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ORONTO this 21st *day of* December, 1993

THIS IS A TRUE COPY OF THE ORIGINAL CERTIFICATE SIGNED BY W. GREGSON, P. ENG.

MAILED ON DEC 2 3 1993

BY [signature]

ict Manager - MOEE Thunder Bay
.A. Masemann, P. Eng., Proctor & Redfern Limited
tor, Water Resources Branch, Attn: K. Roberts

Evaluation of Minimum Residual Chlorine Concentration Required for Inactivation of Giardia Cysts

Appendix C

CARAMAT WATER TREATMENT PLANT

C.1 Evaluation of minimum chlorine residual concentration required for 4-log inactivation of giardia cysts during the winter for the clearwell 1/2 full:

NOTES:

- The SWTR establishes CTs for chlorine, chlorine dioxide, ozone and chloramines which will achieve a min. of 3-log inactivation of giardia cysts. However, it is recommended to use 4-log reduction because of the potential for microbiological contamination in Caramat Lake.

- No credit will be allocated for removal of giardia cysts through the dual media filter and the GAC filter since there is no coagulant dosage performed before the filters. The maximum CT values provided in the Tables are for 3-log inactivation. Therefore, calculation for 3-log inactivation will be performed for discussion purpose.

CT for 3.0-log inactivation = 246 (at 0.5 oC or lower, pH=7.5 and Conc. = 0.8 mg/L)
62 (at 20 oC, pH=7.5 and Conc. <= 0.4 mg/L)

Where C = Concentration (mg/L)
T = Contact Time (min)

Evaluation of contact time (T):

T= [Volume of Clearwell (m3) x %Full x Baffling Condition (T10/T)] / [Maximum Day Flow (m3/d)] x 1,440 min/d

Volume of Clearwell	142	m3
% Full =	0.5	
T10/T =	0.3	
Max. Day Flow =	95	m3/d
Condition =	Winter Time	

T = 323 Minutes

Evaluation of Residual Chlorine Concentration (C):

C = CT for 3.0-log inactivation / T
CT = 246

C =	**0.76 mg/L**

<u>CARAMAT WATER TREATMENT PLANT</u>

C.2 Evaluation of minimum chlorine residual concentration required for 4-log inactivation of giardia cysts during the summer for the clearwell 1/2 full:

NOTES:

* The SWTR establishes CTs for chlorine, chlorine dioxide, ozone and chloramines which will achieve a min. of 3-log inactivation of giardia cysts. However, it is recommended to use 4-log reduction because of the potential for microbiological contamination in Caramat Lake.

* No credit will be allocated for removal of giardia cysts through the dual media filter and the GAC filter since there is no coagulant dosage performed before the filters. The maximum CT values provided in the Tables are for 3-log inactivation. Therefore, calculation for 3-log inactivation will be performed for discussion purpose.

CT for 3.0-log inactivation = 246 (at 0.5 oC or lower, pH=7.5 and Conc. = 0.8 mg/L)
62 (at 20 oC, pH=7.5 and Conc. <= 0.4 mg/L)

Where C = Concentration (mg/L)
T = Contact Time (min)

Evaluation of contact time (T):

T= [Volume of Clearwell (m3) x %Full x Baffling Condition (T10/T)] / [Maximum Day Flow (m3/d)] x 1,440 min/d

Volume of Clearwell	142 m3
% Full =	0.5
T10/T =	0.3
Max. Day Flow =	105 m3/d
Condition =	Summer Time

T = 292 Minutes

Evaluation of Residual Chlorine Concentration (C):

C = CT for 3.0-log inactivation / T
CT = 62

$\boxed{\text{C = } \mathbf{0.21\ mg/L}}$

Analytical Procedures used by Novamann

Appendix D

Detection Limit and Analytical Method Reference used by Novamann

PARAMETERS	MINIMUM DETECTION LIMIT (MDL)	ANALYTICAL METHOD	METHOD REFERENCE*
THM	6 µg/L	Purge &Trap GC/MS	EPA 624
TOC	0.1 mg/L	UV/PEROX/FID	EPA 9060
residual aluminum	0.025 mg/L	ICP	EPA 6010
turbidity	0.1 NTU	Turbidity Meter	APHA 2130
true colour	1 TCU	Colourimetric	APHA 2120
pH	0.01	pH Meter	APHA 4500H
alkalinity	1 mg/L - $CaCO_3$	Titration	APHA 2320
ammonia + ammonium	0.05 mg/L	Colourimetric	APHA 4500
anions (NO_3, Cl, SO_4, F)	0.1 to 0.5 mg/L	Ion Chromatography	EPA 300.0
conductivity	1 umho	Conductivity Meter	APHA 2510
lead	0.002 mg/L	Graphite Furnace	EPA 7421
metals		ICP	EPA 6010
nitrite	0.1 mg/L	Colourimetric	APHA 4500
orthophosphate-P	0.005 mg/L	Colourimetric	APHA 4500

Note *: EPA : Environmental Protection Agency
APHA: American Public Health Association